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Temporal multiplexing for economical measurement of power verses time on NIF

Stan Thomas, Bob Hall and Don T. Davis
Lawrence Livermore National Laboratory
Box 808, L-495, Livermore, CA. 94551

Author	telephone	FAX	e-mail
S.W. Thomas	510-422-5363	510-422-0940	thomas22@llnl.gov
R.P. Hall	510-422-9393		hall16@llnl.gov
D.T. Davis	510-422-8801	510-422-0940	davis14@llnl.gov

(oral presentation preferred)

Abstract

The system design of the National Ignition Facility's (NIF) 192 beam laser incorporates a requirement to measure the time history of the complex-shaped, 22 ns-long, power pulse at three locations on each beam line. The measurements are to be made with a two percent accuracy over a dynamic range of 5000:1 and with a rise-time capability of 250 ps or less. Additionally, back reflected light from several of the optical components in each beam line path between the preamplifier stages and the target chamber will be measured to insure that damage thresholds in the preamplifier sections will not be exceeded. This large number of measurements (768) will be recorded using commercial, high-speed digitizers with long record lengths, and a variety of optical delays.

The preamplifier output at 1.053 μm is injected into the Transport Spatial Filter. One sample is taken at this point in time and delivered to the diagnostics package by a fiberoptic bundle. The injected beam is next passed through the main amplifier, a four-pass amplifier, back through the main amplifier and then returned to the Transport Spatial Filter where a second sample, still at 1.053 μm, is taken. The sample is guided to the Output Sensor by an air path and then to the diagnostic package by a fiberoptic bundle. The time delay between the first and second sample, the time-of-flight through the main and four-pass amplifiers, is about 900 ns.

The beam continues to the target chamber where it is up-converted to 351 nm light by a KD^*P crystal array. A reflection from the crystal output surface is guided back through the optics to the Transport Spatial Filter where a third sample is taken and guided to the diagnostics package, first by an air path (to the Output Sensor) and then by a fiberoptic-cable bundle. The 351 nm sample arrives at the diagnostic package about 1.4 μs after the sample from the preamplifier. The result of the above sample collection scheme is three power samples from one beam line, separated in time by 900 ns and 500 ns, respectively. Similar samples from three more beam lines are combined with the first by delaying each of these by an additional 30, 60 and 90 ns respectively. All these samples are then collected by a fast photodiode and converted to an

electrical input for the digitizer. In this way, four beams are sampled at three points, for a total of 12 samples per digitizer system. For the 576 power measurements, 48 digitizer systems are required. Additional units are required for the backreflection measurement.

The digitizer we selected has only an eight bit converter with 6.3 bits effective resolution, but it has four identical channels per chassis. The four channels are used in parallel, each set to a different full-scale sensitivity, in order to cover the required dynamic range. The digitizer bandwidth is 1 Ghz, and the sample rate is 5 GS/s (5*E9 samples/second). Implementation details, performance data, problems encountered and their solutions are discussed.

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